Department of Mechanical and Manufacturing Engineering

OUTWARD CURVATURE RUNNER WITH AIR VENTS FOR DIE CASTED TEST PIECE BASED ON MANUFACTURABLE MOLD DESIGN

JASMINE ANAK JENDIA

Bachelor of Engineering with Honors

(Mechanical and Manufacturing Engineering)

2019

UNIVERSITI MALAYSIA SARAWAK

Grade:____________

Please tick (√)

Final Year Project Report	✓
Masters	
PhD	

DECLARATION OF ORIGINAL WORK

This declaration is made on the .30...........day of.....MAY......2018.

Student's Declaration:

I JASMINE ANAK JENDIA (50552) FROM DEPARTMENT MECHANICAL AND MANUFACTURING ENGINEERING OF FACULTY OF ENGINEERING hereby declare that the work entitled OUTWARD CURVATURE RUNNER WITH AIR VENTS FOR DIE CASTED TEST PIECE BASED ON MANUFACTURABLE MOLD DESIGN - is my original work. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

30/5/2019
Date submitted

Jasmine anak Jendia (50552)

Supervisor's Declaration:

I IR DR MOHD DANIAL BIN IBRAHIM hereby certifies that the work entitled OUTWARD CURVATURE RUNNER WITH AIR VENTS FOR DIE CASTED TEST PIECE BASED ON MANUFACTURABLE MOLD DESIGN was prepared by the above named student, and was submitted to the "FACULTY" as a * partial/full fulfillment for the conferment of B. ENG. (HONS) IN MECHANICAL AND MANUFACTURING ENGINEERING and the aforementioned work, to the best of my knowledge, is the said student's work.

Received for examination by: ____________________ Date: 2019/5/30

(Ir Dr. Mohd Danial Bin Ibrahim)

IR DR. M. DANIAL IBRAHIM
Senior Lecturer
Department of Mechanical and Manufacturing Engineering
Faculty of Engineering
UNIVERSITI MALAYSIA SARAWAK
94300 Kota Samarahan, Sarawak, Malaysia

I declare that Project/Thesis is classified as (Please tick (√)):

☑ CONFIDENTIAL (Contains confidential information under the Official Secret Act 1972)*

☐ RESTRICTED (Contains restricted information as specified by the organisation where research was done)*

☐ OPEN ACCESS

Validation of Project/Thesis

I therefore duly affirmed with free consent and willingness declare that this said Project/Thesis shall be placed officially in the Centre for Academic Information Services with the abiding interest and rights as follows:

- This Project/Thesis is the sole legal property of Universiti Malaysia Sarawak (UNIMAS).
- The Centre for Academic Information Services has the lawful right to make copies for the purpose of academic and research only and not for other purpose.
- The Centre for Academic Information Services has the lawful right to digitalise the content for the Local Content Database.
- The Centre for Academic Information Services has the lawful right to make copies of the Project/Thesis for academic exchange between Higher Learning Institute.
- No dispute or any claim shall arise from the student itself neither third party on this Project/Thesis once it becomes the sole property of UNIMAS.
- This Project/Thesis or any material, data and information related to it shall not be distributed, published or disclosed to any party by the student except with UNIMAS permission.

Student signature ____________ (Date) 30/5/2019

Supervisor signature: ____________ (Date) 2019/5/30

Current Address:
NO 75, LORONG 2B, TAMAN KWONG THIUNG, 92500, BATU KAWA, KUCHING, SARAWAK.

Notes: * If the Project/Thesis is **CONFIDENTIAL** or **RESTRICTED**, please attach together as annexure a letter from the organisation with the period and reasons of confidentiality and restriction.

[The instrument is duly prepared by The Centre for Academic Information Services

APPROVAL SHEET

This project report which entitled “Outward Curvature Runner with Air Vents for Die Casted Test Piece Based on Manufacturable Mold Design” was prepared by Jasmine anak Jendia (50552) is hereby read and approved by:

___________________ Date: ___________________

Ir Dr. Mohd Danial Ibrahim

Project Supervisor

OUTWARD CURVATURE RUNNER WITH AIR VENTS FOR DIE CASTED TEST PIECE BASED ON MANUFACTURABLE MOLD DESIGN

JASMINE ANAK JENDIA

A dissertation submitted in partial fulfillment

of the requirement for the degree of

Bachelor of Engineering with Honours

(Mechanical and Manufacturing Engineering)

Faculty of Engineering

Universiti Malaysia Sarawak

2019

Dedicated to My Beloved Family and Friends.

ACKNOWLEDGMENT

First and foremost, I would like to thank my supervisor, Ir Dr. Mohd Danial Bin Ibrahim for his advice and guidance in completing this research. Special acknowledgment to my family, Jendia Anak Anyid, Nongie Anak Gatey, Justine Anak Jendia and Joanna Anak Jendia for their infinite love and encouragement to me throughout this research completion. Sincere thanks to collaborators, Dr. Yuta Sunami and Mr. Yuki Kashiwabara from Tokai University, Mr. Hitoshi Watanabe from Kyokuto Die-casting Japan and Mr. Mohd Rosli from HICOM Die-casting Malaysia for their unlimited support. A special acknowledgment goes to my senior, Tan Ger Lian for her valuable advice and guidance. My sincere thanks to everyone who has guided me directly and indirectly, I could not express how much gratitude towards those who helped me but sincerely wishes all of them best of everything now and then.

ABSTRACT

Die casting is a manufacturing process used to produce complex and precise products where molten material is injected into the mold cavity at a very high speed and pressure. Metal injection molding manufacturing is gradually increasing due to the demand for lightweight and sustainable material. Magnesium has several unique physical properties that are comparable with Aluminum metal. In this research, the objective is to study the effect of modification on runner and installation of air vents in reducing investigated defects location. The design of the cavity in this project is a ‘test piece’, an inspection instrument. Design modeling and the relevant parameter is input into ANSYS software for numerical simulation. Novelty runner and gate design (Outward curvature runner with air vent) to enhance fluid behavior inside the cavity are discussed in this paper. Effect of inserting different plugger speed and inserting vacuum also found in this research study. Found that, the modified design could improve the distribution of velocity and temperature of molten metal inside the mold cavity. The modified design also have optimized the fluid flow and eliminate the vortex formation.

ABSTRAK

Die casting adalah proses pembuatan yang digunakan untuk menghasilkan produk yang kompleks dan bertepatan dengan reka bentuk yang diingini. *Die casting* merupakan proses di mana logam yang dileburkan akan dimasukan ke rongga acuan pada kelajuan dan tekanan yang sangat tinggi. Pemintaan produk logam yang ringan dan dihasilkan melalui proses *Die Casting* meningkat dari tahun ke tahun. Magnesium mempunyai beberapa ciri fizikal unik yang boleh dibandingkan dengan logam aluminium. Objektif kajian ini adalah untuk mengkaji kesan pengubahsuaian reka bentuk acuan dan pemasangan laluan udara pada acuan asal dalam mengurangkan kecacatan yang diselidiki. Proses pembuatan *'Test Piece'* melalui proses *Die Casting* merupakan fokus utama kajian ini, *'Test Piece'* merupakan sebuah instrumen yang digunakan untuk mengukur. Simulasi akan dijalankan pada rekabentuk acuan yang telah diubah dan parameter yang relevan akan digunakan sebagai input dalam perisian ANSYS. Kebolehan rekabentuk acuan yang telah diperbahrui *(Outward curvature runner with air vents)* dalam meningkatkan sifat bendalir di dalam acuan akan dibincangkan dalam karya ini. Penyelidikan ini juga merangkumi kesan kelajuan pergerakan logam yang berbeza dan tekanan rendah terhadap sifat logam lebur di dalam acuan. Didapati bahawa reka bentuk yang telah diubah suai dapat mengoptimumkan mengagihan halaju dan suhu logam lebur di dalam acuan. Reka bentuk yang diubah suai juga turut mengoptimumkan aliran bendalir dan menghapuskan pembentukan pusaran.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

A	Area
ADC 12	Aluminium Alloy
AM50A	Magnesium Alloy Type 2
AZ91D	Magnesium Alloy Type 1
CAD	Computer Aided Design
CFD	Computational Fluid Dynamic
FEA	Finite Element Analysis
HPDC	High Pressure Die Casting
MIM	Metal Injection Molding
MPa	Mega Pascals
MRI153M	High Creep Resistance Magnesium Alloys
MRI230D	Magnesium Alloy Type 3
UTS	Ultimate Tensile Strength (Pa)
Q	Volume Flow Rate (m3/s)
YTS	Yield Tensile Strength (Pa)

e	Specific Energy (J/kg)
k	Specific Kinetic Energy (J/kg)
pv	Specific Flow Energy (J/kg)
q	Specific Heat (J/kgK)
Re	Reynold Number
u	Specific Velocity (m/kgs)
w	Specific Work Done (J/s)

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Die casting is a manufacturing process of metal products by injection of molten metal into the mold cavity with high pressure, then the molten metal was left in the cavity till solidified and finally ejected out from the cavity as a product. Die casting is majorly applicable for a non-ferrous and high variety of products (Ravi, 2011). High Pressure Die Casting (HPDC) and High Vacuum Die Casting are some examples of the die casting process. HPDC is widely adapted in die casting manufacturing industries due to their ability to manufactured thin to medium wall thickness product. HPDC process is highly recommended among die casting industries due to its cost-effective process and high production rate benefits. HPDC also served for the manufacture of plastics products (Moscovitch et. al, 2006).

The raw material uses for metal injection molding process is initially in granular size. The metal or plastics granules are then loaded into the feeder and transferred into a cylindrical shape with the aid of screw that will push the fluid at high pressure approaching the nozzle for injection. The metal granules are heated in the cylinder at high temperature and turn into molten metal. Metal granular is injected with high pressure and temperature to ensure solidification process takes place inside the cavity (Lohmüller Et al., 2003).

According to Rosof (1989), there are four basic steps in the metal injection molding process: mixing, molding, debinding and lastly sintering. In the mixing process, the fine metal powder will be mix with binders in the ratio of 1:1 before undergoes injection molding process. The molten metal then will be injected into two half mold clamp together. After the molten metal solidified, the product will be ejected out from the mold cavity together with the runner, overflows and air vents. The finishing process such as assembly, milling, polishing or drilling will fall on the secondary process (Rosof, 1989).

The thixomolding method is an advanced method in die casting according to Energy Efficiency and Renewable Energy (EERE), (n.d.). The thixomolding method had replaced the traditional method of die casting, which lead to a higher production rate, lower manufacturing waste, and better workplace material handling. Figure 1.1 show schematic drawing of Thixomolding:

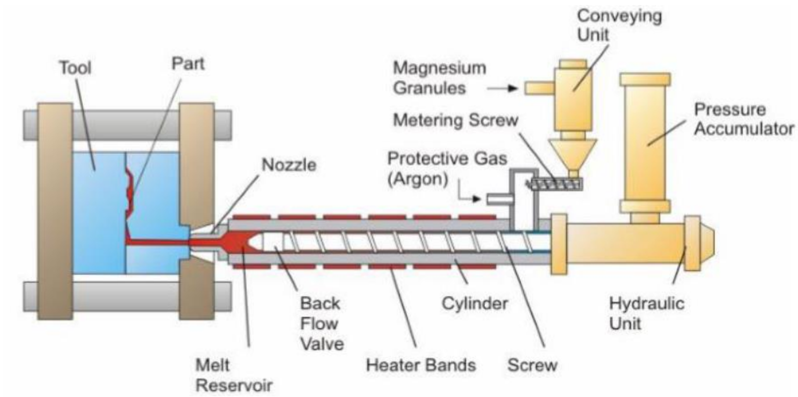

Figure 1.1: Schematic Drawing of Thixomolding® Machine *(Kainer, K. U. (ed.), 2003)*

Table 1.1 shows the components inside an injection molding machine and its function:

Table 1.1: Main Components and Function of Thixomolding

Component	Function
Feeder	- Load metal granules
	- Transfer granules to the cylinder
Screw	- Transfer granule to the nozzle at cylinder front
	- Has valves to prevent backflow
Cylinder	- Heat up metal granules to molten metal
Nozzle	- Inject the molten metal to the mold cavity

1.1.1 Market Demand on MIM Machine

Figure 1.2 shows the growing demand for metal injection molding (MIM) process over the years. The metal injection molding demand is higher in manufacturing of medical and industrial parts. The growth of metal injection molding products in automotive industries is due to the demand for lightweight and sustainable materials parts (Grand View Research, 2016).

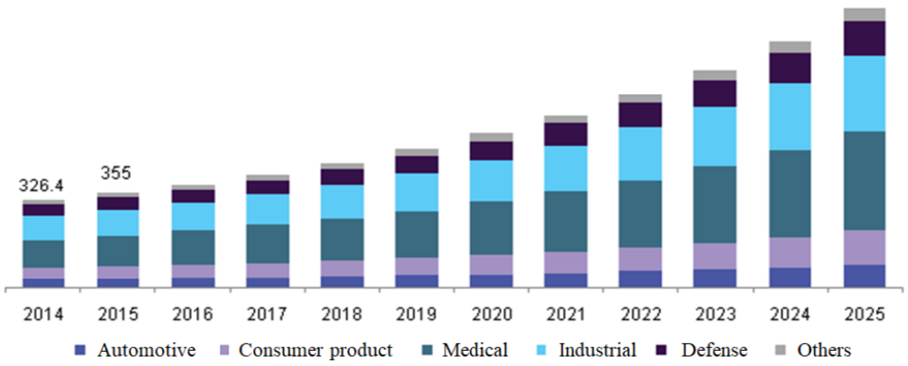

Figure 1.2: U.S. MIM Market by End-use, 2014 - 2025 (USD Million) (*Grand view Research, 2016*)

Figure 1.3 shows the metal injection molding demand in the Asia Pacific. A high percentage of the metal injection molding demand in the production of consumer product, automotive parts and industrial use due to industrial revolution and technology advancement. The growth of the demands had also benefited the Growth Domestic Product (GDP) and estimated to increase until the year 2025 (Grand View Research, 2016).

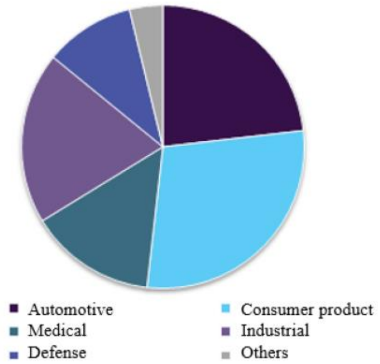

Figure 1.3: MIM Market Share by End-use on the Year 2015 (*Grand view Research, 2016*)

1.1.2 Magnesium Metal and Alloys

According to research and previous studies, the usage of Magnesium had expanded from aerospace, automotive parts to small and difficult components, hardware, and casing. Magnesium is used to manufacture military craft and as nuclear development back in World War I and II era (Mordike and Ebert, 2001). The excellent physical properties of magnesium such as lightweight making it suitable for hand-held carry and reduce the weight of high-speed transportation.

Study on a comparison between Magnesium metal and Aluminium has been conducted. The growing demand in the usage of Magnesium alloy among manufacturers is due to its excellent fluidity behaviors, that has better resistance towards hydrogen peroxide, resulting low casting defects compare to aluminum and copper (Luo,2013). Other than that, Magnesium alloy is eleven times easier to be cast compare to Aluminium alloys, this has led to a high production rate and low manufacturing cost (Fallis, 2013). The lower melting points of aluminum cause higher temperature required to preheat the aluminum granules before being injected into the mold cavity. Aluminum also has lower solidus temperature which causes a lower solidification rate, lead to the long manufacturing process. Thus, the production of Magnesium die-cast product could be the new market demand.

Magnesium alloys are a mixture of Aluminium, Iron and Manganese. Manganese is used to prevent corrosion and provide better binding. Manganese compound will later be separated during the melting process; thus, this alloy is safe to be consumed by humans (Luo, 2013).